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INVESTIGATION OF SEAWATER DEGRADATION OF MECHANICAL PROPERTIES ON GLASS/EPOXY, ISOPOLYESTER AND VINYLESTER COMPOSITES

KANCHIRAYA S[1] & SHIVAKUMAR S[2]

[1]Research Scholar, VTU, Belgaum

[2]Professor, Department of I & PE, GIT, Belgaum

ABSTRACT

The objective of the study is to evaluate the effects of seawater and temperature on the structural properties of glass/epoxy isopolyester and vinylester composite materials. All polymer composites prepared by hand lay-up technique and after curing the specimens expose to artificial sea water for different duration. These effects were studied in terms of seawater absorption and degradation in mechanical properties. Testing of specimens includes immersion time (days) and temperature at 60^0C. It is observed that high temperature accelerates the degradation mechanism in glass/epoxy isopolyester and vinylester composites and increase the weight of materials due to seawater absorption.

KEYWORDS: Degradation Studies, FRP, Artificial Seawater

INTRODUCTION

Fiber reinforced plastics (FRP) are extensively employed in a wide variety of applications like sports equipment, airplanes, electric devices, space craft and so on due to their light weight, high reliability and competitive prices [1]. FRP's also have high specific tensile and compressive strength, with improved fatigue, and corrosive resistance. They are suitable for production of complex shape components with reduced manufacturing cost compared to conventional materials [2-3]. FRP structures develop the interest in many boat builders due to their non corrosive properties. Some of FRP structures degraded by seawater and marine organisms and therefore ongoing maintenance and repairs that was expensive. The selection of type of fiber reinforcement plastics with design and processing techniques were improved the properties even in the underwater environment [4]. The fibre/matrix interfaces of polyester based composites in the moisture environment were degraded by hydrolysis reaction of unsaturated groups within the resin [4]. Moisture absorption reduces the glass transition temperature, mechanical properties and debonding at the fiber/matrix interface [5]. This problems more severe in physio-chemical and thermo mechanical conditions or hygrothermal ageing conditions. The water penetrates the composite via cracks and voids in the matrix and diffuses through the matrix resulting in reversible plasticization [6]. Many researchers worked on effect of moisture degradation of various FRP structures separately but no of few research work focused in the same study. The objective of the work was to explore the properties of a hand lay-up processed of FRP materials, and also attempted to analyze the effect of saltwater and hygrothermal on mechanical properties of processed FRP'S structures.

MATERIAL AND SAMPLE PREPARATION

The specimens of polymer composite used in the present research were glass/epoxy, glass/ isopolyester and glass/ vinylester. The specimens were fabricated using wet hand layup process. Before lay-up, the mould surfaces are polished thoroughly and teflon mould was applied with a mould releasing agent (paraffin wax) to ensure smooth removal of the

laminate from the mould and to avoid its adhesion to the mould. The fibre matrix ratio of 65: 35 wt % was maintained for all the specimens. The operator should use soft brushes to impregnate the fibres with the resin. While laying it is necessary to ensure air bubble and wrinkling do not occur and atmospheric condition is important to ensure good mechanical properties. Hydraulically operated hot press of 2 ton capacity was used for the final pressing of the laminate stacked in the mould to ensure the uniform distribution of the resin throughout the laminate. The pressing in the hot press machine also improves the uniform wetting of the fibre used in the laminate. The uniform wetting and bonding of the fibre and matrix helps to improve the fibre / matrix interphase in the composite. It also helps faster curing of the laminates, by minimizing the number of imperfections and voids of the laminates. The expected thickness of the laminate can be ensured through the pressing in the hot press machine. Hence, uniform pressure was applied on the laminates at room temperature using hydroulic press. The specimen were cured at room temperature for two weeks as most of the materials for marine applications are naturally cured, before exposing to experimental conditions. The details of accelerated testing methodology can be obtained from earlier research works [7-9]. Specimen were cut to the recommended length, tensile specimen 3mm average thickness were prepared from each material type according to ASTM standard, for tensile strength d-638, flexural strength d 790, inter laminar shear strength test d 2344 [10]. For hygrothermic conditioning the specifications of environmental chamber temperature range of 20 to 200 °C, humidity range of 90%, rate of heating and cooling 3°c/min. The experimental conditions were 95%rh and 60 °C for a period of 196 days.

RESULTS AND DISCUSSIONS

Moisture Absorption Test

The rate of change of weight and thickness swelling of the specimens due to water absorption in 180 days duration to determine the rate and amount of water absorption in the materials. Seawater intake at room temperature was 1.36% at 6 month by weight in glass/epoxy composite and 2.82% at 65^0C. For glass/Isopolyester samples seawater intake was 1.76% at room temperature and at 65^0C, it was 3.26%, glass/Vinylester seawater intake was 1.48% at room temperature and 3.06% at 65^0C respectively. From these data that high temperature activates the diffusion of water molecules through the composites. High rate of absorption were seen in glass/Isopolyester composites exposed to distilled water at 65°C.

Hygrothermic Durability Studies

Ultimate tensile strength (UTS) of the specimens exposed to hygrothermic conditioning obtained by the experimental results was analysed and performance prediction was done based on the ultimate tensile strength results over a duration of 196 days at temperature 60°C and 95% rh. For UTS of glass/isopolyester specimens the degradation was 54.34% and glass/vinylester is 21.975 at 60°C. For glass/epoxy samples the degradation 19.51% at same temperature shown in Figure 1. It is apparent from these data at high temperature the glass/epoxy showed higher strength than

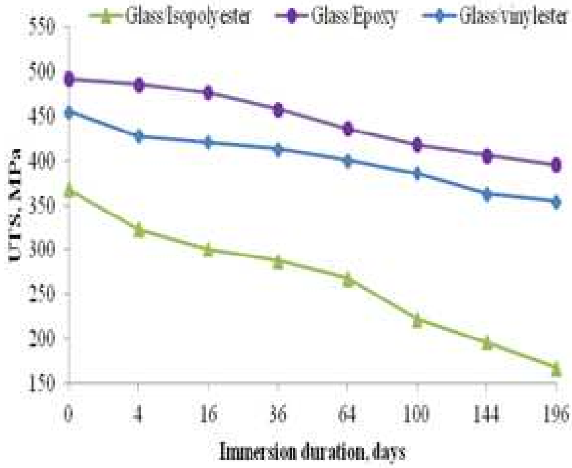

Figure 1: Ultimate Tensile Strength Versus Duration Due to HYGROTHERMIC Condition at 60C, 95% RH

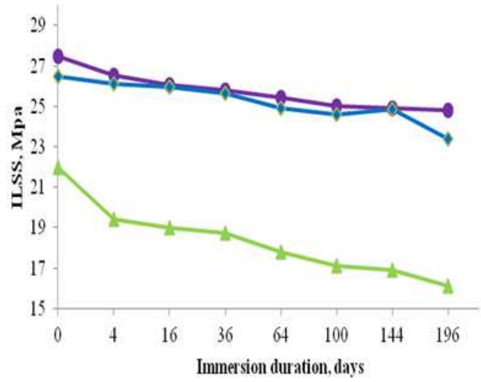

Figure 2: Inter Laminar Shear Strength Versus Duration Due to Hygrothermic Condition at 60C, 95% RH

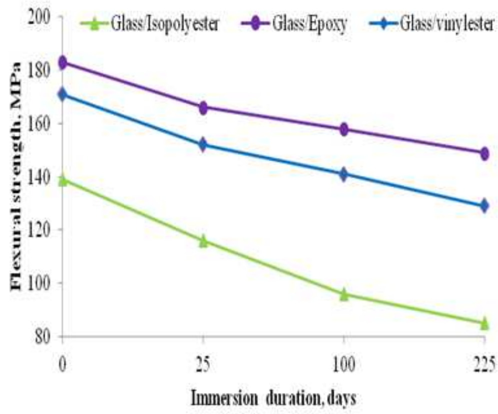

Figure 3: Flexure Strength Versus Duration Due to Hygrothermic Condition at 60C, 95% RH

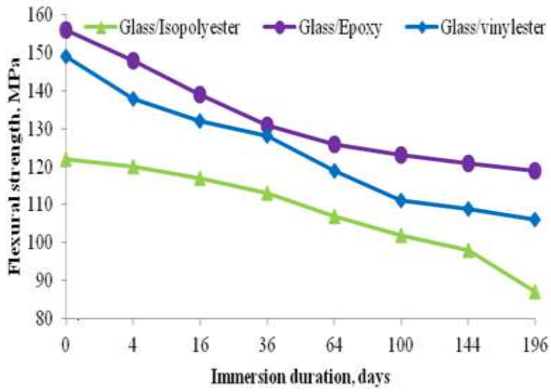

Figure 4: Flexural Strength Degradation Verses Duration of Saltwater Immersion

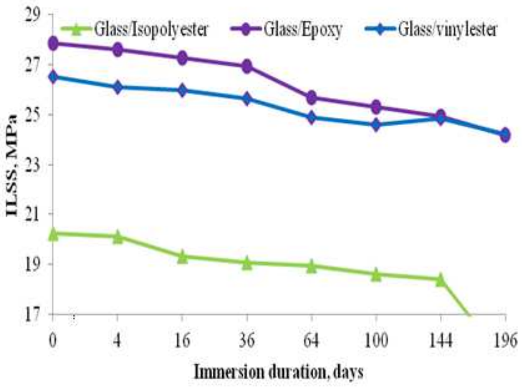

Figure 5: Inter Laminar Shear Strength Degradation Verses Duration of Saltwater Immersion

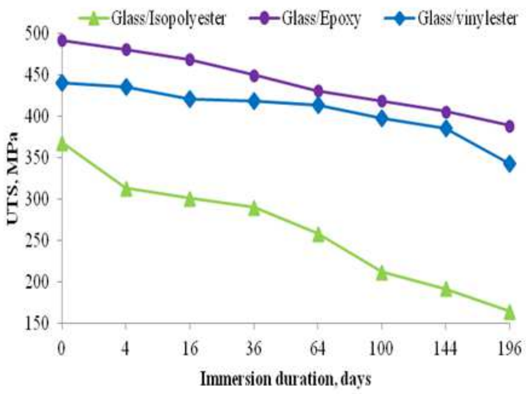

Figure 6: Ultimate Tensile Strength Degradation Verses Duration of Saltwater Immersion

Glass/Isopolyester and glass/vinylester. The trend in inter laminar shear strength degradation behavior shown in figure 2. Ilss is one of the important properties for composites, which determines the load sharing by the fibers, that is the interfacial strength. Glass/Isopolyester and glass/vinylester samples are showed 26.77% and 11.69%. For glass/epoxy

specimens 9.7% showed at 60 °C for a duration of 196 days at hygrothermic conditions. The flexural strength behavior was observed is very similar to inter laminar shear strength show in figure 3. The flexural strength of glass/isopolyester and glass/vinylester at 60^0C is 38.84%and 20.46. For glass/epoxy 18.59% for 196 days at hygrothermic condition.

All the composite materials showed degradation in flexural strength, ultimate tensile strength and inter laminar shear strength due to hygrothermic conditioning, glass/isopolyester showed greater degradation than glass/epoxy ,degradation increased with increase in temperature water penetrates into the interface through the micro voids and micro cracks and trapped water damages the interface region where it trapped. The longer duration of exposure, the water diffusion will be slowed because of the water saturation in the matrix phase.

Strength Degradation Due to Artificial Seawater Immersion

Figure 4 shows change in flexural strength of glass/isopolyester, glass/vinylester and epoxy/glass FRP with respect to different sea water immersion times (days). Th rough all the specimens showed drop in isopolyester composites with respect to immersion time because of moisture uptake. Glass/isopolyester specimens should higher levels of degradation, it shows 55.43%, glass/vinylester specimen degradation is 22.24%, for epoxy 20.93%. Epoxy composites showed higher strengths than the isopolyester and vinylester. The trend in the inter laminar shear strength degradation behavior was observed and shown in figure. 5 ilss is one of the important properties for composites, which determines the load sharing by the fibers. Epoxy/glass samples showed superior stability on inter laminar shear strength degradation and 13.28% of drop and glass/isopolyester and glass/vinylester showed a percentage drop of 28.68% and 12.15%. Artificial seawater in the resins could causes vibration and rotation on the cross link that may break the bonds. Surface changes in the glass/isopolyester and glass/vinylester fibers on salt water immersion reduces the strength of the fiber by an extent also the reason for degradation in the ilss in the material reinforced. A progression change in tensile strength as a function of immersion time is shown in figure 6. The specimens immersed in saltwater, it is clearly indicates that the immersion time increase substantially with increase in degradation. The rate of percentage degradation was observed to be higher in initial stage. The ultimate tensile strength degradation was more in glass/isopolyester 40.61%, glass/vinylester is 28.855% and glass/epoxy drops 23.71%.

CONCLUSIONS

This paper presents the behavior of isopolyester/glass, glass/vinylester and epoxy/glass reinforced polymer composites after artificial seawater exposure and hygrothermal ageing was studied experimentally. Hygrothermic behavior of FRP was studied by exposing them to 60°C for maximum duration for 196 days. Absorption of seawater increased gradually with immersion time and with higher temperature the mechanical property degradation.

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